

Short-Term Health Effects Associated with Exposure to Air Pollution During Exercise



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**Air Resources Board
California Environmental Protection Agency**

Thank you Mr. Goldstene. Good morning, Chairman Nichols and members of the Board. In this health update, I am going to discuss a study that investigated the association between air pollution and short-term health effects among people who were exposed while exercising. This presentation will focus on health effects found in adults, particularly those with asthma.

Athletes: A Vulnerable Population

- During exercise people breathe:
 - Faster
 - Through their mouths
 - Deeper
- Athletes receive higher doses of air pollution than the general public
 - Particularly those who exercise near traffic such as joggers, bicycle commuters, and pedestrians



2

Children, the elderly, and immuno-compromised individuals are particularly susceptible to the effects of air pollution. One vulnerable group that is often overlooked are those who work or exercise outdoors. During exercise, people breathe faster, a greater proportion of air is inhaled through the mouth, bypassing nasal filtration, and pollutants are carried more deeply into the lungs. Greater volumes of air are exchanged during exercise, up to 10 or 20 times more air compared to when at rest.

Likewise the quantity of pollutants inhaled increases. Anyone exercising outdoors during times of high pollution, such as during the recent wildfires in California, should remember they will receive a greater dose of pollutants. People who exercise near roadways such as joggers, cyclists, and pedestrians experience increased risk because not only are they exposed to ambient air pollution but traffic-related pollution as well.

Respiratory Effects of Exposure to Diesel Traffic in Asthmatics

- 60 adults with mild or moderate asthma in London
- Walked 2 hours twice:
 - In an area of heavy diesel traffic
 - In an area of no traffic
- Real-time information on:
 - Pollution exposure
 - Physiological measurements

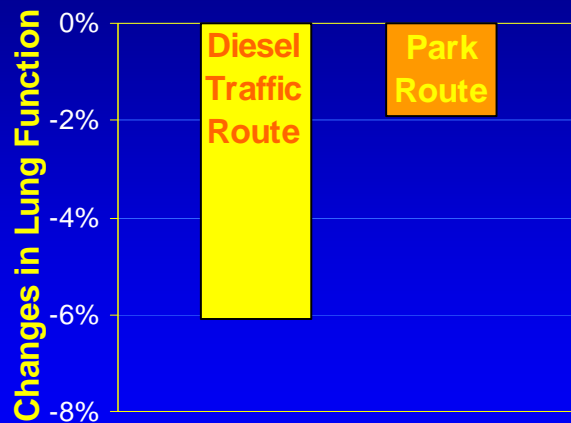


McCreanor J, et al. Respiratory effects of exposure to diesel traffic in persons with asthma. *N Engl J Med* 2007;357:2348-58. Supported by the Health Effects Institute.

3

In the study I am focusing on today, Dr. McCreanor and colleagues of Imperial College in London examined the impact of diesel traffic on 60 asthmatic adults while exercising. Each participant walked for 2 hours along a London street that contained exclusively diesel traffic and, on a separate occasion, through a nearby park. During both walking sessions, detailed real-time information was gathered on pollution exposure and physiological measurements such as lung function and markers of inflammation. The results of these measurements are shown on the next slide.

Decreases in Lung Function among Asthmatic Adults after Exercise



4

The researchers found that when the participants walked next to busy streets they had significantly higher exposures to fine and ultrafine particles, elemental carbon, and nitrogen dioxide than when they walked in the park. The lung function results of the study are shown in this graph. The yellow bar represents the percentage decrease in lung function after walking near diesel traffic, while the orange bar shows the decrease after walking in the park. The lung function decrease following exposure to high diesel traffic was more than three times the decrease observed after exercising in the park. Traffic-exposed participants also experienced large increases in markers of inflammation, which were mostly absent after walking in the park. These changes were most consistently associated with exposures to ultrafine particles and elemental carbon, which are the pollutants most associated with diesel vehicles.

Health Effects after Exercising in Air Pollution

- 4-X ↑ DNA damage after cycling in traffic
- 3-5% ↓ in lung function with ozone exposure while cycling
- 3-X ↓ in ability to deliver oxygen to the heart while exposed to diesel exhaust during exercise
- 3-X ↑ asthma development among children in high ozone areas who played multiple outdoor sports



5

There are a number of other studies that have also found adverse health effects linked to exercise and air pollution exposure. For example, a Danish study found that after bicycling in traffic the level of DNA base damage was increased 4-fold compared with the level measured after bicycling indoors¹. A few studies have found ozone-associated lung function decreases immediately following exertion among cyclists. One of these studies followed a cycling team throughout the summer and found that with increasing ozone levels, short-term lung function decreased up to 5%². In a laboratory study of heart attack survivors, researchers found that the ability to deliver oxygen to the heart following moderate exercise was reduced 3-fold while exposed to dilute diesel exhaust compared to clean air³. The Children's Health Study, originally funded by the ARB, found that children who participated in several outdoor sports and lived in communities with high ozone levels were three times more likely to develop asthma than children with the same activity level living in areas with less ozone pollution⁴.

1. Vinzents, P. S., et al. (2005). "Personal exposure to ultrafine particles and oxidative DNA damage." *Environ Health Perspect* 113(11): 1485-90.
2. Brunekreef, B., et al. (1994). "Respiratory effects of low-level photochemical air pollution in amateur cyclists." *Am J Respir Crit Care Med* 150(4): 962-6.
3. Mills N.L. et al. (2007). "Ischemic and Thrombotic Effects of Dilute Diesel-Exhaust Inhalation in Men with Coronary Heart Disease." *NEJM* 357(11): 1075-82.
4. McConnell R. et al. (2002). Asthma in exercising children exposed to ozone: a cohort study. *Lancet* 360:386-91.

ARB Projects

- **Current**

- Ultrafine particle exposure and short-term respiratory outcomes among bicycle commuters



- **Planned**

- Comparison of particulate matter exposure among different commuting modes

- **ARB's Bicycle Awareness Program**

<http://www.arb.ca.gov/planning/tsaq/bicycle/bicycle.htm>



6

ARB has two in-house projects related to exercise and exposure to air pollution. We recently completed data collection in a study that is examining changes in short-term lung function with respect to ultrafine particle exposures among long-distance bicycle commuters. Results should be released early next year. In the autumn, we plan to compare particulate exposure among four different commuting modes: car, bicycle, train, and bus.

ARB also has a bicycle awareness program which contains useful information about the air quality benefits of cycling as well as suggestions on how to overcome barriers to cycling in our communities.

Exercise Promotes Good Health

- Increases clearance of pollutants
- Increases the body's antioxidant activity
- Improves quality of life
 - Fewer sick days
 - Better cardiac and respiratory health
 - Live longer



7

It is well established that exercise promotes health and fitness. Regular exercise can help counteract the negative health effects of air pollution. For example, regular activity has been shown to increase respiratory clearance, which should improve removal of inhaled particles from the lungs. Immune function and the body's antioxidant activity strengthens with exercise. Also, people who exercise use fewer sick days, have better cardiac and respiratory health, and live longer. There is evidence the longevity effect is more pronounced specifically in athletes who are bicycle commuters¹.

1. Andersen, L. B., P. Moller, et al. (2000). "All-cause mortality associated with physical activity during leisure time, work, sports, and cycling to work." Arch Intern Med. 160:1621-28.

Conclusions and Recommendations

Athletes should consider:

- Health advisory press releases
- Air quality advisories
- Route and location

• Communities should ensure:

- Air quality alerts reach their audience
- Land development includes plans to encourage cyclists and pedestrians



8

Individuals who exercise on days of poor air quality or near traffic are likely to experience increased exposures to air pollution. But it is possible to minimize these exposures. They can heed advisories such as those issued by ARB that provide information on steps the public can take to reduce their exposure to air pollution during high pollution episodes such as the recent wildfires. Local air pollution control districts use the air quality index to advise both the general public and sensitive groups on activities they should avoid. Also, bicycle commuters, joggers, and pedestrians can consider alternate, less heavily-traveled routes.

Communities should ensure that air quality alerts are reaching their intended audiences via their outreach programs. For example, the South Coast Air Quality Management District supports a program where special flags are displayed at local schools indicating the current air quality.

An increased physical separation between motor vehicles and pedestrians and cyclists would be another means of minimizing particle exposure to these individuals. Making our communities more bicycle and pedestrian friendly will not only help counter obesity and its myriad of accompanying health problems, but also help reduce air pollution and greenhouse gas emissions. This concludes my presentation. We will be happy to answer any questions you may have.